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Processing of Digital Data Logger STD Tapes at the Scripps Institution of Oceanography and the Bureau of Commercial Fisheries, La Jolla, California

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UNITED STATES DEPARTMENT OF THE INTERIOR
U.S. Fish and Wildlife Service
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By
JAMES H. JONES

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ABSTRACT

The development of continuous sampling STD (salinity-temperature-depth) sensors as a prime data collection tool for oceanographic cruises has necessitated the development of techniques capable of handling the data with modern digital computing equipment. This paper describes one such technique that was developed for processing STD data collected as part of the EASTROPAC Survey Program. The description assumes that the data has been digitized and recorded on IBM compatible tape in the field. The computer programs needed for processing the basic data tapes are described, and a listing of the program with subroutines is given in the Appendix.

Processing of Digital Data Logger STD Tapes at the Scripps Institution of Oceanography and the Bureau of Commercial Fisheries, La Jolla, California

By

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INTRODUCTION

As part of the EASTROPAC Survey Program, computer programs were developed to process STD (salinity-temperature-depth) data from Bisset-Berman model 9006 systems,[2] and record them on incremental IBM compatible DDL's (digital data loggers), also manufactured by the same company. The accuracy and precision of these two instruments are described in the manufacturing brochures and are not discussed here. During the EASTROPAC Program, about 10,000 m. of field tapes were generated which required editing and data processing.

The purpose of this paper is to describe the methods developed for processing the field tapes to a point where the data produced from them may be compared with some independent calibration such as conventional Nansen casts or Niskin samplers, attached to the STD's.

In its present form, the DDL samples each of four channels of information about once every 0.2 second, and writes a seven-channel IBM compatible tape at a bit density of 200 bits per inch. At a drop rate of 60 m. depth per minute, salinity, temperature, depth, and the optional sound velocity channel are sampled five times in each 1-m. interval. Since the uncertainty of the depth sensor is about 1 m., at this maximum sampling rate, five values of temperature and salinity are available to produce one value per meter. The program described below is based on the premise that the original field tapes are recorded at this maximum rate. Slower sampling rates require slight modification of the low-pass filters used in the program. The fourth and optional channel of sound velocity is not used on any STD systems of the Scripps Institution of Oceanography, or the Bureau of Commercial Fisheries; therefore no description of schemes to process the optional channel is included.

PRELIMINARY PROCESSING

When the field tapes are received at the data-processing center they are first passed through a computer routine which examines

[1]Work for this manuscript was done while the author was employed by the Bureau of Commercial Fisheries Fishery-Oceanography Center, La Jolla, Calif. 92037.

[2]Use of trade names does not imply endorsement by the Bureau of Commercial Fisheries.

them, file by file, and lists the binary length of the first record as well as the total number of records per file. Any parity errors in the records examined are also listed.

The ideal field tape contains no parity errors. The first record of the first file is an information record and, in the format used by us, is a three-digit number signifying the cast number for that particular cruise. The binary length of this record is always 1. The second file consists of the data recorded by the data logger and may contain any number of records depending, among other things, on the maximum depth attained and the drop rate. A 500-m. cast at a drop rate of 60 m. per minute has about 50 records per file.

In its present form the data logger is designed to produce a binary data record length of 52.[3] Thus, in the ideal field tape the files alternate between an information file containing only one record with a binary length of 1 and a data file with many records, all with a binary length of 52. The preliminary listing of the field tapes provides the programmer with a picture of how far his tapes deviate from the ideal. If the contents of the first record are printed during the preliminary listing, the cast numbers may be identified with individual data files.

The next step in the data processing is to produce, from the field tapes, a high-density tape which is free of parity errors and other anomalies which confuse the tape translation. In the transfer from low- to high-density tape, we have chosen to eliminate all records containing parity errors and records not of binary length 1 or 52. Our experience is that we lose no more than 3 percent of the original data in this way. The high-density tape, free of tape errors, is then considered to be the basic data; the original field tapes are erased, checked and readied for the next cruise.

THE PROGRAM

The program and subroutine functions are outlined in figure 1, and a listing of the program, as run on the CDC 3600 at UCSD (University of California, San Diego), is provided in the Appendix. The main program RDEDTP (read and edit tape) reads in, from cards, a list of the files to be translated from the basic tape and a list of station numbers that are to be associated with data lists. The file containing the station number is read and translated if it is in the proper format. If it is missing or in an improper format, as determined from the preliminary tape listing, the proper station number is determined from a logbook for the data logger and is read in from a card.

The first subroutine, TRANS, translates, record by record, the digitized frequencies into salinity in parts per thousand, temperature in degrees Celsius, and depth in meters. Maximum and minimum bounds are specified for the depth so that any values outside these limits are rejected.

During the field operations, the sensor package is sometimes temporarily stopped at an intermediate depth to make adjustments to the pens or the winch. The data logger is usually left running on these stops, but the records are of no use in producing a vertical profile; subroutine BASKET is accordingly called to delete the records where the depth has not increased. The final control is a counter which provides for a jump out of TRANS before memory overflows can occur.

A sample output of the record produced by subroutine TRANS is given in figure 2. The fourth column of each set is an absolute counter for the file, which increases only when an acceptable set of salinity, temperature, and depth is translated. When the lower depth bounds are exceeded, the counter is not increased and that set of data is not saved for transmittal to the smoothing subroutine. The 0's printed at the beginning of the file in the first record indicate nonacceptable data, since the depth is less than the minimum of -0.2 m. set in the subroutine. In the first record of this file only 16 sets of salinity, temperature, and depth were acceptable.

Between TRANS and the next subroutine, the maximum and minimum values of salinity,

[3]The magnetic tape record is 416 tape frames long, which is the equivalent of 52 computer records.

COMPUTER PROGRAM LINKAGE
FOR
PROCESSING DIGITAL STD TAPES

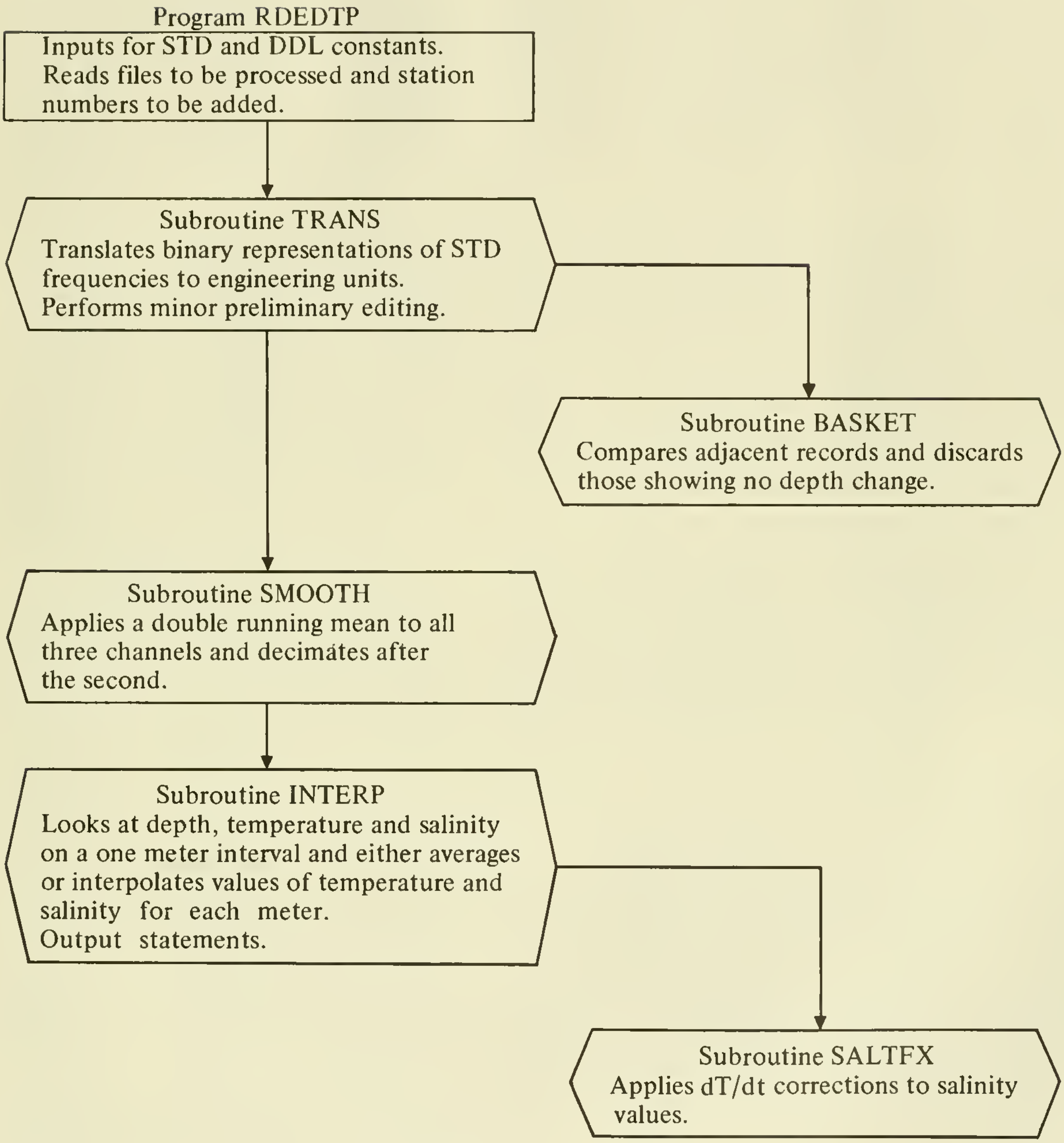

Figure 1.—Computer program linkage for processing digital STD tapes.

-.5	21.56	34.941	-0	-.6	21.55	34.940	-0	-.5	21.57	34.940	-0	-.3	21.57	34.939	-0
-.1	21.57	34.938	1	-.5	21.56	34.949	-0	-.3	21.56	34.953	-0	-.5	21.56	34.947	-0
-.5	21.57	34.938	-0	-.5	21.58	34.934	-0	-.5	21.60	34.929	-0	-.6	21.59	34.933	-0
-.6	21.60	34.942	-0	-.5	21.60	34.944	-0	-.5	21.60	34.945	-0	-.5	21.60	34.950	-0
-.3	21.59	34.951	-0	-.1	21.60	34.942	2	-.1	21.59	34.952	3	.1	21.59	34.966	4
.5	21.60	34.972	5	.7	21.63	34.987	6	.7	21.66	34.982	7	.7	21.66	34.944	8
1.1	21.66	34.950	9	1.4	21.65	34.944	10	1.1	21.65	34.958	11	1.6	21.65	34.918	12
1.6	21.66	34.941	13	1.8	21.66	34.944	14	2.0	21.64	34.947	15	2.2	21.64	34.949	16
2.9	21.62	34.960	17	2.9	21.61	34.768	18	3.1	21.61	34.697	19	3.1	21.58	34.931	20
3.3	21.50	34.792	21	3.3	21.46	34.820	22	3.9	21.35	34.849	23	3.3	21.27	34.876	24
3.7	21.20	34.884	25	4.3	21.11	34.867	26	4.5	21.04	34.892	27	4.5	21.02	34.892	28
4.5	20.94	34.898	29	5.0	20.89	34.902	30	4.8	20.84	34.896	31	5.0	20.80	34.910	32
4.8	20.77	34.914	33	5.4	20.73	34.926	34	5.2	20.71	34.928	35	5.8	20.66	34.935	36
6.0	21.65	34.934	37	6.3	20.62	34.950	38	6.0	20.60	34.870	39	6.5	20.57	34.882	40
6.5	20.55	34.904	41	6.9	20.52	34.937	42	7.1	20.51	34.949	43	7.3	20.51	34.943	44
7.5	20.49	34.631	45	8.1	20.21	34.385	46	7.9	19.97	34.514	47	8.2	19.68	34.720	48
8.6	19.22	34.796	49	8.6	19.13	34.765	50	8.8	19.01	34.813	51	9.6	18.94	35.096	52
9.0	19.08	34.968	53	9.9	18.99	34.925	54	9.6	19.05	35.086	55	9.9	19.42	35.359	56
9.8	19.89	35.160	57	9.9	19.88	34.701	58	10.5	19.47	34.659	59	10.5	18.92	34.646	60
10.3	18.77	35.145	61	10.5	18.79	34.715	62	11.1	18.58	34.500	63	11.3	18.29	34.046	64
11.1	18.04	34.581	65	11.3	17.99	34.797	66	11.7	17.60	34.155	67	11.7	17.15	34.245	68
12.0	16.97	34.392	69	12.2	15.90	34.448	70	12.8	16.86	34.573	71	13.2	16.86	34.673	72
13.2	16.84	34.775	73	13.7	16.84	34.820	74	14.3	16.80	34.847	75	14.1	16.78	34.859	76
14.9	16.76	34.880	77	14.7	16.75	34.807	78	15.1	16.74	34.901	79	15.1	16.74	34.901	80
15.3	16.71	34.903	81	16.2	16.71	34.910	82	15.8	16.70	34.914	83	15.3	16.70	34.920	84
16.0	16.71	34.928	85	16.2	16.69	34.944	86	15.6	16.70	34.959	87	16.4	16.70	34.968	88
16.6	16.68	34.972	89	16.8	16.68	34.971	90	16.8	16.68	34.973	91	16.6	16.68	34.976	92
17.1	16.68	34.973	93	17.7	16.68	34.973	94	17.3	16.68	34.969	95	17.1	16.66	34.972	96
17.7	16.67	34.971	97	18.3	16.67	34.971	98	18.3	16.67	34.966	99	18.5	16.66	34.956	100
18.7	16.64	34.948	101	19.2	16.64	34.959	102	19.6	16.63	34.963	103	19.8	16.62	34.967	104
20.2	16.63	34.968	105	20.4	16.62	34.968	106	20.6	16.62	34.976	107	21.1	16.62	34.979	108
21.3	16.63	34.972	109	21.1	16.60	34.973	110	21.3	16.61	34.978	111	21.3	16.61	34.980	112
21.5	16.61	34.980	113	21.1	16.60	34.981	114	21.1	16.60	34.980	115	21.1	16.60	34.979	116
21.7	16.60	34.979	117	21.9	16.61	34.977	118	22.3	16.60	34.973	119	22.5	16.58	34.953	120
22.5	16.55	34.939	121	22.8	16.50	34.944	122	23.4	16.46	34.941	123	23.0	16.44	34.955	124
24.0	16.42	34.951	125	24.4	16.40	34.950	126	24.6	16.38	34.952	127	24.9	16.35	34.951	128
25.1	16.33	34.953	129	25.5	16.33	34.961	130	25.7	16.32	34.966	131	26.1	16.31	34.962	132
26.1	16.29	34.956	133	26.5	16.27	34.961	134	26.5	16.27	34.966	135	27.0	16.25	34.970	136
26.6	16.21	34.972	137	26.6	16.19	34.970	138	26.6	16.19	34.970	139	26.6	16.16	34.960	140
27.4	16.14	34.963	141	27.2	16.12	34.966	142	27.2	16.09	34.970	143	27.8	16.09	34.958	144
27.8	16.05	34.959	145	28.7	16.04	34.962	146	28.5	16.04	34.967	147	28.5	16.02	34.975	148
29.1	16.01	34.980	149	29.5	15.99	34.973	150	30.1	15.99	34.978	151	30.1	15.98	34.983	152
30.4	15.98	34.987	153	30.8	15.97	34.989	154	31.2	15.98	34.991	155	31.0	15.98	34.992	156
31.2	15.97	34.992	157	31.0	15.96	34.992	158	31.4	15.97	34.993	159	31.8	15.95	34.994	160
32.0	15.96	34.994	161	31.4	15.96	34.995	162	31.8	15.95	34.995	163	31.4	15.96	34.995	164
32.3	15.95	34.995	165	32.2	15.95	34.994	166	31.6	15.97	34.994	167	32.2	15.96	34.994	168
32.3	15.94	34.992	169	32.7	15.96	34.994	170	33.3	15.96	34.994	171	32.9	15.93	34.990	172
32.9	15.95	34.992	173	33.5	15.95	34.993	174	33.9	15.94	34.992	175	34.1	15.93	34.993	176

Figure 2.–Salinity, temperature, and depth values translated by subroutine TRANS. The fourth column is a counter which increases only when a value is acceptable for transmission to subroutine SMOOTH. The 0 counter values at the top of the first page denote inacceptable observations as the depth falls outside the minimum limit. The station was EASTROPAC 75.115, an STD cast to a nominal depth of 150 m.

temperature, and depth as well as the total number of values retained are printed. This printing gives a check that determines whether any unrealistic values were used in the subsequent filtering and averaging routines.

The third subroutine, SMOOTH, performs low-pass filtering to the three channels and decimates. The low-pass filters are a running mean; the numbers for the averages depend on the recording and drop rates. Since our procedures normally produce about five values every meter, a running mean of 5 is applied. Decimation occurs after the second running mean and depth values are rounded to the closest 1-m. interval.

The final subroutine, INTERP (interpret), is an averaging and interpolation package. Values of temperature and salinity that occur in the same 1-m. interval are averaged. Where there are no values in a meter interval, one is linearly interpolated from adjacent values. After this procedure, subroutine SALTFX (salt fix) is called and salinity values are corrected for swift changes in the temperature gradient according to the formula:

$$S = \left(\frac{\partial T}{\partial z}\right) R \tau K S'$$

where S' is the apparent salinity

$\frac{\partial T}{\partial z}$ is the rate of change of temperature with depth

K is a constant (~ -0.09 p.p.t. per 1°C.)

τ is a thermometer time constant (~0.35 sec.)

and R is the drop rate.

A final output statement follows this last subroutine.

Figure 3 represents the final output from the data-processing program. Preceding the data are the station number and the total number of observations within the bounds set in TRANS and transmitted to subroutine SMOOTH. Below are the maximum and minimum values of salinity, temperature, and depth used by the smoothing subroutine. Finally, the number of data sets transmitted from SMOOTH to the final subroutine INTERP are given. The data interpolated to a 1-m. interval follow below.

A comparison of the DDL output with the analog output of the STD is presented in figures 4-6. A 600-m. station was chosen for the comparison as it presents most of the features normally encountered on an STD cast. Figure 4 is a reproduction of a cast made near the equator in the eastern Pacific. The surface temperature and salinity noted at the top of the trace were determined from a continuous recording surface TS recorder, periodically checked by bucket temperature and surface-water sample salinity. The numbers adjacent to the profiles represent the salinity scale (4) and the temperature scales (6, ..., 3) used during the cast. The salinity trace is displaced upward (toward a shallower depth), by 5 m. on the depth scale, from the temperature to allow the two pens to cross without interfering with one another. This particular paper does not have the scales printed directly, but they are identical to those at the bottom of figure 5. The spikes in the salinity trace are a feature common to almost all STD casts. They are considered to be a result of a failure of the electronic system in the salinity sensor to respond to sudden changes of the temperature gradient and do not reflect the true salinity at those locations.

Figure 5 is a computer generated plot of the 1-m. values as output from the data processing program. The scales are identical to those of figure 4. The temperature profile is identical to the analog plot reproducing fully temperature inversions and sudden changes in gradient. The salinity trace, when the vertical pen displacement is accounted for, is also reproduced with some spikes totally eliminated and others partially eliminated. The failure to eliminate all the salinity spikes reflects the fact that not all the spike-forming processes are known. The manufacturer has recently noted that there is an intermittency in a portion of the electronic system that responds to a sudden change in temperature gradient as well as a lag response function in the operation of the conductivity to salinity circuitry. The manufacturer

claims to have remedied this circuitry problem in the newer model 9040 STD system. In addition, the numbers used in the salinity correction formula given above are only approximate and may be seriously in error for some instruments and for very different drop rates than assumed here.

It is for these reasons that additional filtering is applied to the salinity trace alone. Figure 6 presents a running mean of 10, applied to the salinities used to produce the profile in figure 5. The type of secondary salinity filtering will ultimately depend on the user's application of the data.

STATION 511

ORIGINAL NO OF OBS. 815

MAX.TEMP. 21.66 MIN.TEMP. 13.17 MAX.SAL. 35.359 MIN.SAL. 34.046 MAX.DEPTH 156.8 MIN.DEPTH -.1

NUMBER OF DATA PTS.AFTER SMOOTHING 262

VALUES INTERPOLATED AT 1 METER INTERVALS

DEPTH (M)	TEMP (OC)	SALN (O/OO)	DEPTH (M)	TEMP (OC)	SALN (O/OO)	DEPTH (M)	TEMP (OC)	SALN (O/OO)	DEPTH (M)	TEMP (OC)	SALN (O/OO)
1	21.64	34.955	2	21.64	34.934	3	21.55	34.838	4	21.17	35.002
5	20.83	34.984	6	20.64	34.926	7	20.53	34.996	8	19.99	34.919
9	19.10	34.954	10	19.26	35.057	11	18.16	34.869	12	17.12	34.632
13	16.86	34.653	14	16.80	34.822	15	16.74	34.978	16	16.70	34.945
17	16.68	34.975	18	16.67	34.973	19	16.64	34.965	20	16.63	34.970
21	16.61	34.981	22	16.58	34.989	23	16.48	34.979	24	16.40	34.970
25	16.34	34.965	26	16.30	34.981	27	16.20	35.005	28	16.08	34.994
29	16.02	34.986	30	15.98	34.990	31	15.97	34.994	32	15.96	34.996
33	15.95	34.994	34	15.94	34.994	35	15.94	34.993	36	15.94	34.993
37	15.94	34.993	38	15.94	34.993	39	15.94	34.994	40	15.92	34.992
41	15.91	34.987	42	15.90	34.984	43	15.89	34.977	44	15.87	34.969
45	15.81	34.986	46	15.71	34.990	47	15.63	34.997	48	15.56	35.000
49	15.52	34.992	50	15.51	34.981	51	15.48	34.993	52	15.44	34.999
53	15.41	34.991	54	15.39	34.986	55	15.36	34.990	56	15.35	34.985
57	15.33	34.980	58	15.31	34.990	59	15.27	34.997	60	15.25	34.994
61	15.24	34.988	62	15.20	34.986	63	15.15	34.988	64	15.06	34.997
65	14.98	34.995	66	14.94	34.989	67	14.90	34.993	68	14.86	34.997
69	14.83	34.994	70	14.82	34.995	71	14.81	34.998	72	14.81	34.988
73	14.80	34.946	74	14.74	34.963	75	14.40	35.079	76	13.86	35.091
77	13.71	34.983	78	13.69	34.959	79	13.68	34.967	80	13.66	34.973
81	13.64	34.973	82	13.64	34.971	83	13.63	34.971	84	13.63	34.971
85	13.62	34.970	86	13.62	34.968	87	13.63	34.969	88	13.62	34.971
89	13.62	34.971	90	13.62	34.970	91	13.61	34.969	92	13.61	34.969
93	13.61	34.968	94	13.60	34.969	95	13.59	34.969	96	13.59	34.968
97	13.59	34.968	98	13.58	34.968	99	13.58	34.967	100	13.58	34.967
101	13.58	34.968	102	13.57	34.967	103	13.57	34.967	104	13.56	34.967
105	13.56	34.965	106	13.55	34.966	107	13.54	34.965	108	13.54	34.963
109	13.52	34.969	110	13.49	34.969	111	13.48	34.959	112	13.46	34.954
113	13.45	34.957	114	13.43	34.960	115	13.42	34.962	116	13.41	34.959
117	13.40	34.956	118	13.40	34.956	119	13.40	34.957	120	13.40	34.957
121	13.40	34.958	122	13.40	34.957	123	13.40	34.957	124	13.39	34.957
125	13.39	34.954	126	13.39	34.955	127	13.38	34.955	128	13.38	34.956
129	13.37	34.956	130	13.37	34.954	131	13.37	34.954	132	13.37	34.954
133	13.37	34.955	134	13.36	34.954	135	13.37	34.954	136	13.36	34.954
137	13.36	34.953	138	13.36	34.959	139	13.34	34.952	140	13.34	34.950
141	13.32	34.949	142	13.30	34.948	143	13.28	34.948	144	13.26	34.947
145	13.24	34.949	146	13.21	34.950	147	13.19	34.945	148	13.19	34.942
149	13.19	34.944	150	13.18	34.944	151	13.18	34.943	152	13.18	34.942
153	13.18	34.943	154	13.18	34.943	155	13.18	34.943	156	13.18	34.943
157	13.18	34.945									

Figure 3.–Final output of acceptable values at 1-m. intervals from subroutine INTERP. The station number is printed at the top. Below is the number of observations transmitted to subroutine SMOOTH. The maximum and minimum values transmitted of salinity, temperature, and depth are listed below the numbers of observations. The number of data points after smoothing indicates the number of observations transmitted to subroutine INTERP. (One observation consisted of one value of each of salinity, temperature, and depth.)

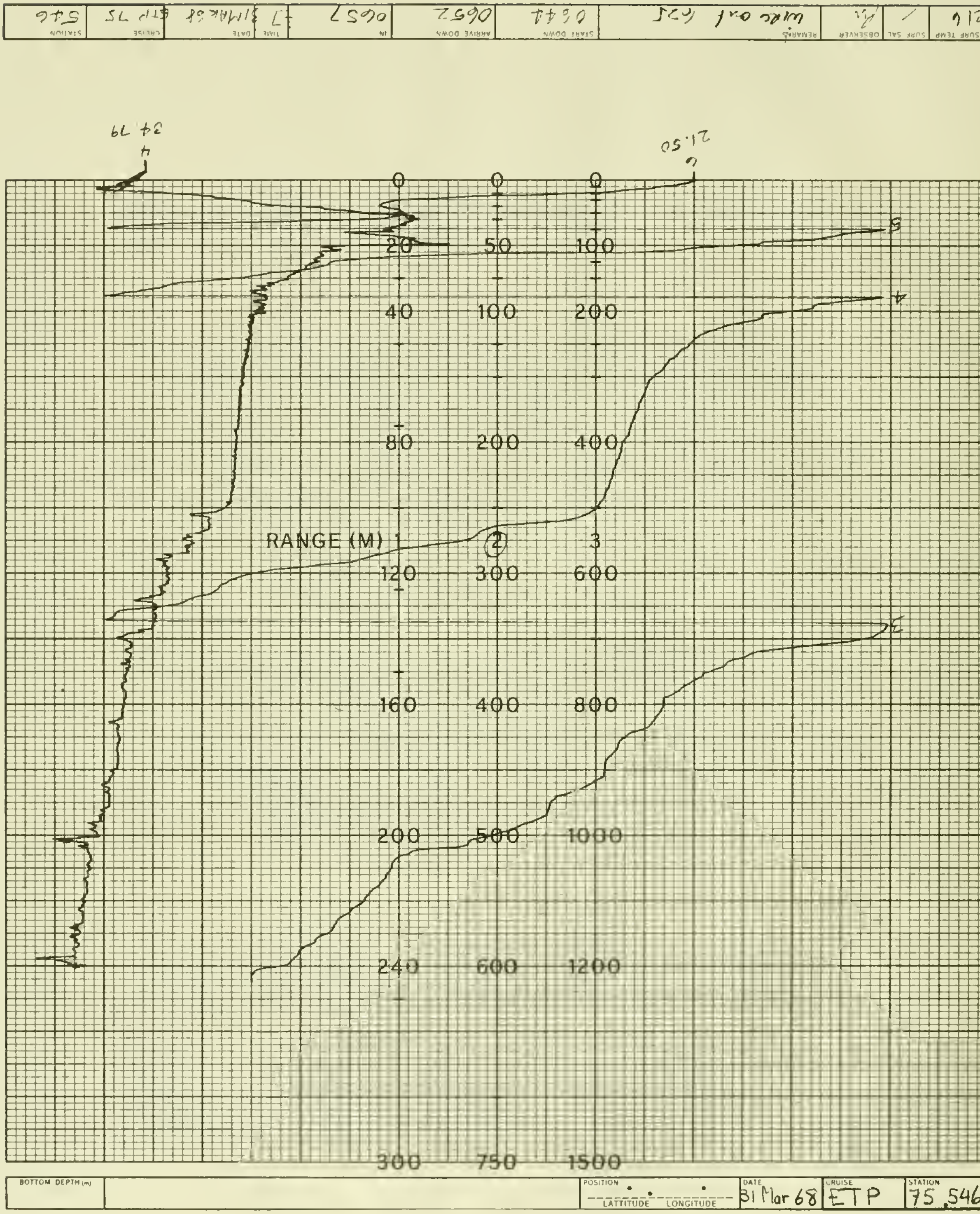

Figure 4.–Reproduction of original analog trace of station 546, made on EASTROPAC cruise 75 (15 February to 15 April 1968). Cast was to 600 m. Surface salinity and temperature at top of figure were determined from continuous recording surface TS recorder.

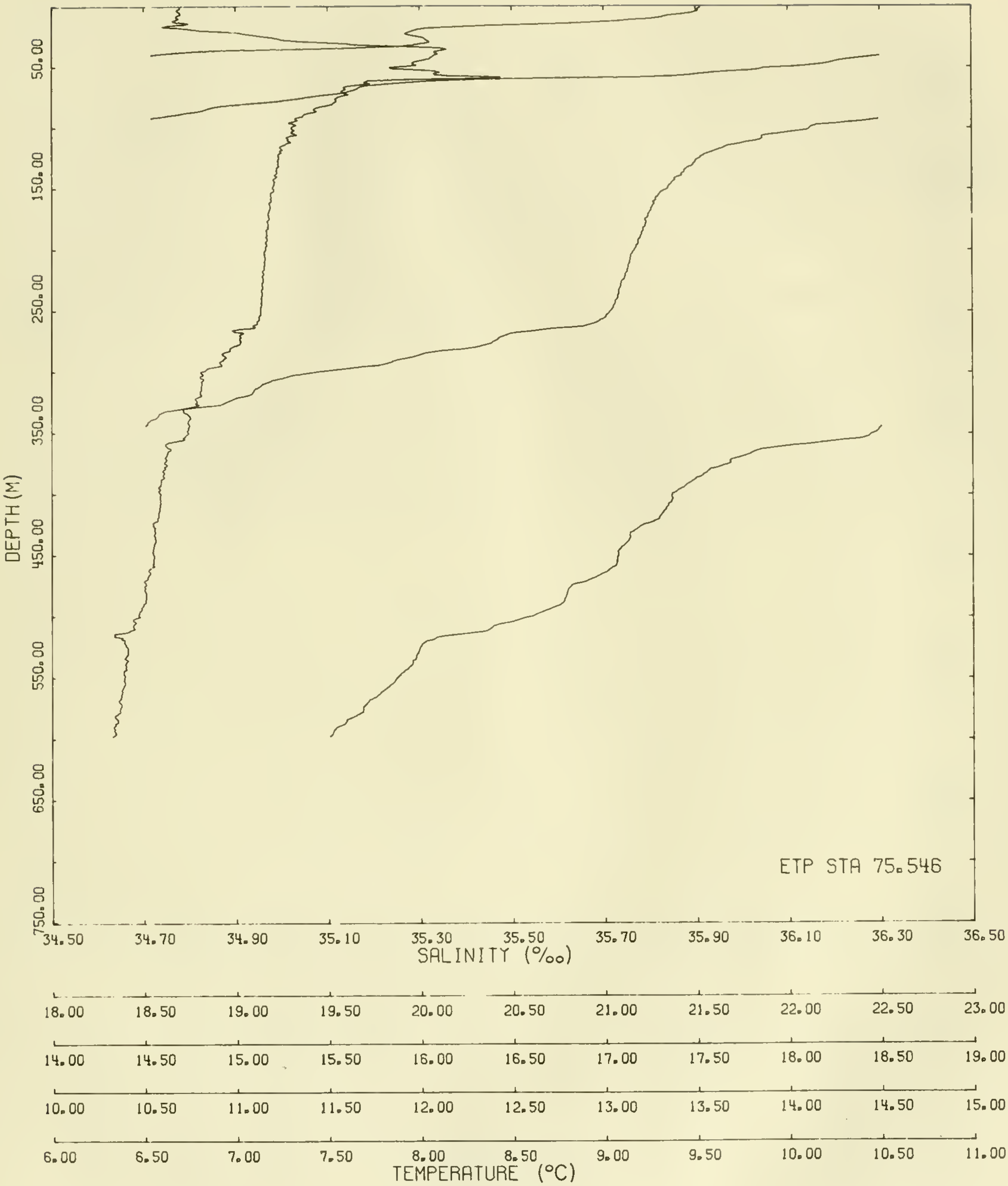

Figure 5.–A plot of the processed digital data logger values as output from the data processing program. Salinity, temperature, and depth scales are identical to those in figure 4.

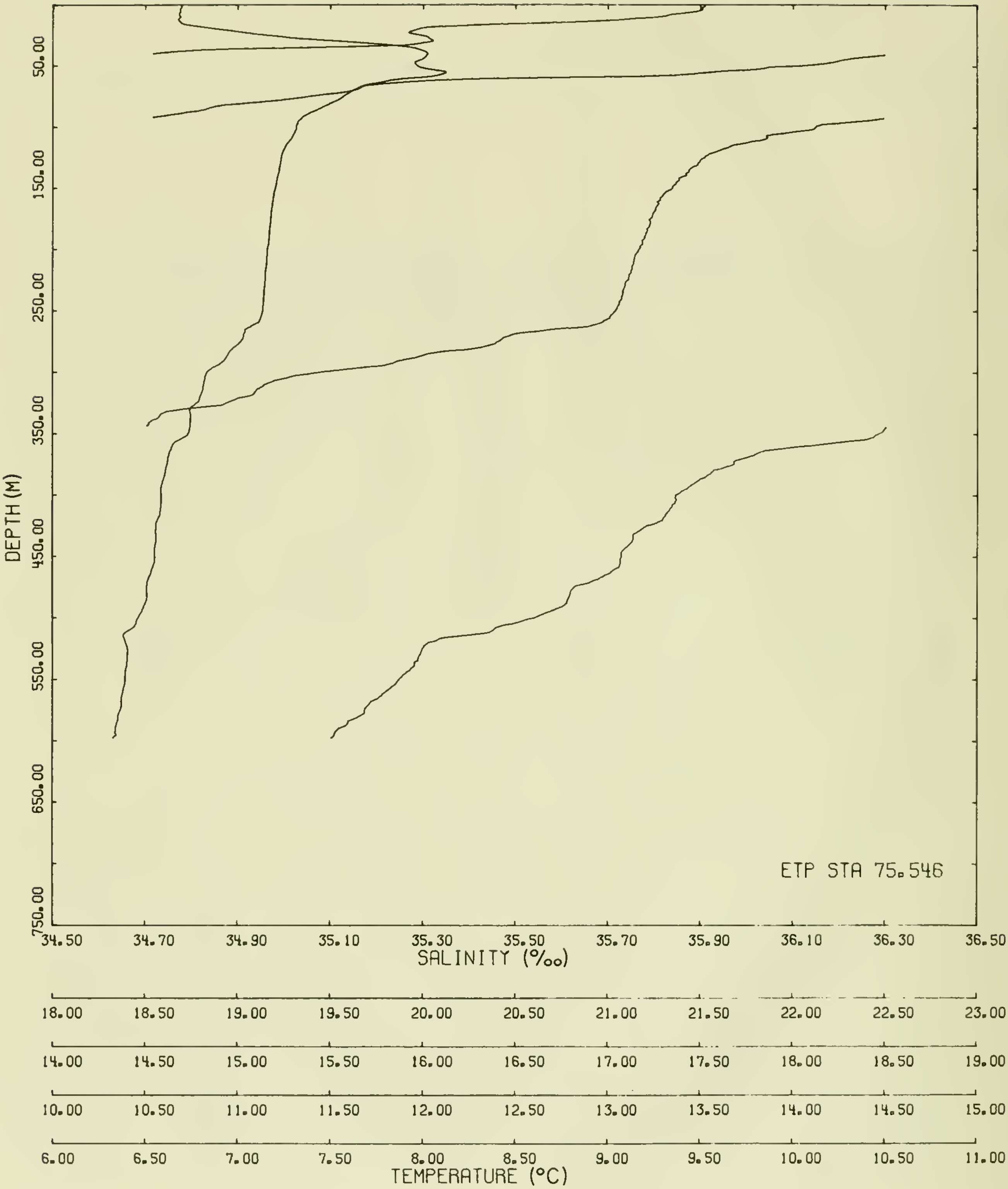

Figure 6.--Plot of processed values with additional filtering applied to the salinity values. The scales are identical to those in figure 5.

CONCLUSIONS

The computer program discussed here presents one approach to the data processing of STD digital data logger tapes. There are undoubtedly many alternative techniques which may do just as well. The system described above, however, has the virtue of having been used for nearly 2 years, and it is felt that this program produces a set of data which most nearly represents the signals generated by the STD sensor package, in a form easily interpreted by most of those who need to work with the data.

The additional problems of relating these data with independent measurements and of eliminating random and systemic errors are peculiar to individual instruments, cruises, personnel, and techniques, and almost always must be determined by the experimentor. The method used on the EASTROPAC data was to take the output of the program described here, compare these data with the independent calibrations, and then correct on the computer for any drift or offset noted during the cruise. In addition, the salinity trace is filtered to produce a profile similar to that shown in figure 6.

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APPENDIX

A listing of Program RDEDTP and subroutines as used on the University of California, San Diego CDC 3600 computer. Questions concerning individual library subroutines should be directed to the UCSD computer center, La Jolla, Calif. 92037.

```
          PROGRAM RDEDTP                                                     1
C    THIS PROGRAM IS FOR PROCESSING DDL TAPES WITH BIN. LTH. 52, 4 CHANLS
          TYPE INTEGER A,B,C ,FLSTA                                          2
          DIMENSION A(80),KK(8)                                              3
          DIMENSION NFILE(500),ISTFL(100)                                    4
          COMMON     DD(3300),TT(3300),SS(3300),MO,ISTA                      5
          COMMON     TM,TB,SM,SE,DM,D3,DEPK,SALK,TEMPK                       6
C    THESE CONSTANTS ARE FOR THE SIO DDL AS OF 2/68
          DEPK=95. $ SALK=63. $ TEMPK=7.                                     7 - 9
C    THIS SET OF DATA CARDS ARE FOR SIO NO. 2 FISH
          DFMIN=9712. $ DFMAX=11288. $ DMIN=0. $ DMAX=1500.                 10 - 13
          TFMIN=2127. $ TFMAX=4193. $ TMIN=-2. $ TMAX=35.                   14 - 17
          SFMIN=4995. $ SFMAX=7901. $ SMIN=30. $ SMAX=40.                   18 - 21
          TM=(TMAX-TMIN)/(TFMAX-TFMIN)                                      22
          TB=(TMIN*TFMAX-TFMIN*TMAX)/(TFMAX-TFMIN)                          23
          DM=(DMAX-DMIN)/(DFMAX-DFMIN)                                      24
          DB=(DMIN*DFMAX-DFMIN*DMAX)/(DFMAX-DFMIN)                          25
          SM=(SMAX-SMIN)/(SFMAX-SFMIN)                                      26
          SB=(SMIN*SFMAX-SFMIN*SMAX)/(SFMAX-SFMIN)                          27
C    NUMFIL IS THE NUMBER OF FILES TO BE TRANSLATED
C    NFILE(I) ARE THE FILES TO BE PROCESSED
C    NOSTA2 IS THE NUMBER OF OF FILES WITH NO HEADING INFO
C    ISTFL(I) ARE THE FILES THAT NEED STATION NUMBERS
C    ILL IS THE FIRST FILE TO BE PROCESSED
C    IFLMAX IS THE LAST FILE TO BE PROCESSED
          READ 22,NUMFIL $ READ 21, (NFILE(I),I=1,NUMFIL)                   28   29
          READ 22, NOSTA2 $ READ 21,(ISTFL(I),I=1,NOSTA2)                   30   31
   21     FORMAT (16I5)                                                     32
   22     FORMAT (I5)                                                       33
          IFLMAX=116                                                        34
          NS=1 $ ILL=1                                                      35   36
   60     NF=NFILE(ILL) $ CALL TAPEPOS (11,NF,0) $ ILL=ILL+1                37 - 39
          BUFFER IN (11,1) (A(1),A(52))                                     40
  100     IF (UNIT,11) 100,400,60,200                                       41
  200     LL=LENGTHF(11) $ GO TO 401                                        42   43
  400     LL=LENGTHF(11) $ IF (LL.EQ.52) 399,401                            44   45
  399     PRINT 58                                                          46
   58     FORMAT (1H0,32H NO STATION NUMBER FOR THIS CAST )                 47
          ISTA=ISTFL(NS) $ NS=NS+1 $ PRINT 421,ISTA $ BACKSPACE 11          48 - 51
          GO TO 501                                                         52
  401     LK = 8*LL $ DO 406 IBI=1,LL  $ KABC=A(IBI)                        53 - 55
  406     DECODE (8,410,KABC) KK                                            56
  410     FORMAT (  8R1)                                                    57
          ISTA=100*KK(1)+10*KK(2)+KK(3) $ PRINT 421,ISTA                    58   59
  421     FORMAT (14H0 STATION      ,I5)                                    60
          NF=NFILE(ILL) $ CALL TAPEPOS (11,NF,0) $ ILL=ILL+1                61 - 63
  501     CALL TRANS                                                        64
          IFILE=LUFILE (11) $ IF(IFILE.GE.IFLMAX) 900,890                   65   66
  890     GO TO 60                                                          67
  900     CONTINUE                                                          68
          END                                                               69
```

```
      SUBROUTINE TRANS
      TYPE INTEGER A,B,C
      DIMENSION A(80),B(500),KK(8),D(32),T(32),S(32),NO(32),DX(32)
      COMMON    DD(3300),TT(3300),SS(3300),MO,ISTA
      COMMON    TM,TB,SM,SE,DM,DB,DEPK,SALK,TEMPK
      KR=1 $ J2=0 $ JE=0
  499 BUFFER IN (11,1) (A(1),A(80))
  500 IF (UNIT,11) 500,550,800,550
  800 IF (JE)  52,499
  550 LL=LENGTHF(11)
      LK=8*LL $ JE=1 $ IA=1
      DO 600 IY=1,LL $ KABC=A(IY) $ DECODE (8,410,KABC) KK
  410 FORMAT (8R1)
      DO 601 IX=1,8$ B(IA) = KK(IX)
  601 IA =IA +1
  600 I=0  $  DO 49. IV=1,LK,13
      DY = B(IV)*1024 + B(IV+1)*32 + B(IV+2)
      SY = B(IV+3)*1024 + E(IV+4)*32 + B(IV+5)
      TY = B(IV+6)*1024 + E(IV+7)*32 + B(IV+8)
      SV = B(IV+9)*1024 + E(IV+10)*32 + B(IV+11)
      I=I+1
      D(I) =(DM*DEPK*5.E6)/(DY+32768.)+DB
      S(I) =(SM*SALK*5.E6)/(SY+32768.)+SB
      T(I) = (TM*TEMPK*5.E6)/TY+TB
      IF (D(I).GT.1110.,OR.D(I)._T.-.2)491,612
  612 J2=J2+1 $ NO(I)=J2
      DD(J2)=D(I) $ TT(J2)=T(I) $ SS(J2)=S(I) $ DX(I)=D(I)
      GO TO 490
  491 NO(I)=0 $ DX(I)=DD(J2)
  490 CONTINUE
C     PRINT 431,(D(I),T(I),S(I),NO(I),I=1,32) $ PRINT 432
  431 FORMAT (4(X,F6.1,F7.2,F8.3,I5,3X))
  432 FORMAT (1H0)
      IF (J2.GT.3265) 50,51
   50 GO TO 52
   51 CALL BASKET (DX,J2,KR)
      GO TO 499
   52 MO=J2-1
      DMAX=ARRAYMAX(DD,MO) $ DMIN=ARRAYMIN(DD,MO)
      TMAX=ARRAYMAX (TT,MO) $ TMIN=ARRAYMIN (TT,MO)
      SMAX=ARRAYMAX (SS,MO) $ SMIN=ARRAYMIN (SS,MO)
      PRINT 56,MO $ PRINT 57,TMAX,TMIN,SMAX,SMIN,DMAX,DMIN
   56 FORMAT (1H0,20H ORIGINAL NO OF OBS., I5)
   57 FORMAT (1H0,10H MAX.TEMP.,F6.2,2X,10H MIN.TEMP.,F6.2,2X,10H MAX.SA
     1L. ,F7.3,2X,10H MIN.SAL. ,F7.3,2X,10H MAX.DEPTH,F6.1,2X,10H MIN.DE
     2PTH,F6.1)
      CALL SMOOTH
      END
```

```
(6.2A)                                                    JOB 2603  02/25/69   PAGE 1

          SUBROUTINE BASKET (D,J2,KR)
          DIMENSION D(2),DR(300)
          DR(KR)=(D(1)+D(2)+D(3)+D(4)+D(5))/5.
          IF (KR.LE.5) 72,70
     70   IF (IBAD) 74,73
     73   DKP=DR(KR-1)
          IBAD=1
     74   IF(DR(KR).LT.DKP) 69,72
     69   IF (J2.LT.33) 75,71
     71   J2=J2-32
          GO TO 75
     72   IBAD=0
     75   CONTINUE
          KR=KR+1
          END
```

```
      SUBROUTINE SMOOTH
      DIMENSION X(3300),Z(3300),ID(3000)
      COMMON D(3300),T(3300),S(3300),M,ISTA
      K=1
    4 IF (K-2) 20,21,22
   20 DO 5 I=1,M
    5 Z(I)=T(I) $ GO TO 30
   21 DO 6 I=1,M
    6 Z(I)=S(I) $ GO TO 30
   22 DO 7 I=1,M
    7 Z(I)=D(I) $ GO TO 30
   30 X(1)=Z(1) $ X(2)=(Z(1)+Z(2))/2. $ M2=M-2
      DO 10 I=3,M2
   10 X(I)=              (Z(I-2)+Z(I-1)+Z(I)+Z(I+1)+Z(I+2))/5.
      X(M)=Z(M) $ X(M-1)=(Z(M-1)+Z(M))/2.
      IF(K-2)40,41,42
   40 DO 12 I=1,M
   12 T(I)=X(I) $ GO TO 60
   41 DO 13 I=1,M
   13 S(I)=X(I) $ GO TO 60
   42 DO 14 I=1,M
   14 D(I)=X(I) $ GO TO 61
   60 K=K+1$ GO TO 4
   61 CONTINUE
C     PRINT 3,(D(I),T(I),S(I),I,I=1,M)
    3 FORMAT (4(X,F6.1,F7.2,F8.3,I5,3X))
      DO 70 J=3,M,3
      D(J)=(D(J-1)+D(J)+D(J+1))/3. $ T(J)=(T(J-1)+T(J)+T(J+1))/3.
   70 S(J)=(S(J-1)+S(J)+S(J+1))/3. $ J=1
      DO 100 I=3,M,3 $ D(J)=D(I) $ T(J)=T(I) $ S(J)=S(I)      $ J=J+1
  100 JJ=J-1 $ JJP=JJ
      DO 300 I=1,JJP
  300 ID(I)=D(I)+.5 $ L=0 $ K=1
      DO 200 I=2,JJP $ IF(ID(I).GE.ID(K))220,200
  220 L=L+1 $ ID(L)=ID(I) $ T(L)=T(I) $ S(L)=S(I)   $ K=I
  200 CONTINUE
      PRINT 450,L
  450 FORMAT (1H0,36H NUMBER OF DATA PTS.AFTER SMOOTHING ,I5)
      CALL INTERP (L,ID,T,S,ISTA)
      END
```

```
(6.2A)                                                                    JOB 2603   02/25/69    PAGE 1

         SUBROUTINE INTERP (MC,D,T,S,ISTA)                                               1
         DIMENSION D(2),T(2),S(2),DD(1112),TT(1112),SS(1112)                             2
         TYPE INTEGER D,DD                                                               3
         K=0 $ D(2)=D(1)                                                                 4    5
         DO 100 I=1,MO                                                                   6
         M=1 $ IF(D(I+M).EQ.D(I)) 10,14                                                  7    8
 10      M=M+1                                                                           9
         IF(D(I+M).EQ.D(I)) 10,15                                                       10
 15      SUMT=0 $ SUMS=0 $K=K+1 $ XM=FLOATF(M)                                          11 - 14
         DO 30 N=1,M $ SUMT=SLMT+T(I-1+N)                                               15   16
 30      SUMS=SUMS+S(I-1+N)                                                             17
         DD(K)=D(I) $ TT(K)=SLMT/XM $ SS(K)=SUMS/XM $ I=I+M-2                           18 - 21
         GO TO 100                                                                      22
 14      INK=D(I+1)-D(I) $ FINK=FLOATF(INK)                                             23   24
         DO 50 J=1,INK                                                                  25
         K=K+1 $ FJ=FLOATF(J) $ DD(K)=DD(K-1)+1                                         26 - 28
         TT(K)=T(I)+(T(I+1)-T(I))*(FJ/FINK)                                             29
 50      SS(K)=S(I)+(S(I+1)-S(I))*(FJ/FINK)                                             30
         IF (DD(K).EQ.D(I+2)) 51,100                                                    31
 51      K=K-1                                                                          32
100      CONTINUE                                                                       33
         CALL SALTFX (K,SS,TT)                                                          34
         PRINT 20 $ PRINT 440 $ PRINT 441                                               35 - 37
 20      FORMAT (1H0, 48H  VALUES INTERPOLATED AT 1 METER INTERVALS        /)           38
440      FORMAT(1H0,116HDEPTH   TEMP    SALN             DEPTH   TEMP    SALN           39
        1           DEPTH   TEMP    SALN            DEPTH   TEMP    SALN       )
441      FORMAT(1H0,115H  (M)    (0C)    (0/00)              (M)    (0C)    (0/00)      40
        1            (M)    (0C)    (0/00)              (M)    (0C)    (0/00)    /)
         PRINT 1,(DD(I),TT(I),SS(I),I=1,K)                                              41
  1      FORMAT (4(X, I6 ,F7.2,F8.3,8X))                                                42
         PRINT 11                                                                       43
 11      FORMAT (1H1)                                                                   44
C        WRITE (10) ISTA,K $ WRITE(10)(DD(I),TT(I),SS(I),I=1,K)$ ENDFILE 10
         END                                                                            45
```

```
(6.2A)                                                    JOB 2603  02/25/69   PAGE 1

              SUBROUTINE SALTFX (MC,S,T)                                  1
              DIMENSION S(2),T(2)                                         2
              M4=MO-4                                                     3
              DO 130 I=4,M4                                               4
              S(I)=S(I)*(1.-0.0212*1.118*0.35*((T(I+1)+T(I-1))/T(I))*     5
             C(-T(I+3)+9.*(T(I+1)-T(I-1))+T(I-3))/24.)
          130 CONTINUE                                                    6
              END                                                         7
```

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